Abstract Volume

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Progress and Prospects on Water: For a Clean and Healthy World

with Special Focus on Sanitation

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*Workshop 7 was a special half-day workshop with no abstract.

Workshop 5: Cost-effectiveness in Pollution Abatement

An Innovative & Cost-Effective Monitoring Network for Water Pollution Control and Water Management

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Industrial development and pollution, uncontrolled domestic discharges from urban areas, diffuse pollution from agriculture and various alterations in land use or hydro-infrastructure may all contribute to non-sustainable use of water resources. Up to now, water pollution risk is increasing and the environmental degradation is continuing as there is no clear methodology to understand the operational needs that handle inter-related risk and environmental impact due to incompatible information systems that provide easy access to relevant data. Large amount of data (hydrological, geological economic, social economic, demographic, physical, meteorological, etc) is required for the data analysis and water management. There is a need to develop shared information systems for water pollution control and water management which will promote model and systems integration and monitoring. The developed monitoring network will be designed to consider several levels of planning and decision making through the management system of spatially referenced data with advanced computer simulation, graphical visualisation, and dynamic optimization. Therefore, this paper is effectively link into wider strategic aims of bringing together innovative ways of thinking based on knowledge and technology in many scientific disciplines (e.g., dynamic optimisation, geo-information technology, environmental impact assessment, spatial and environmental planning, and water management etc.) to achieve more effective water pollution control. The monitoring network will take into account all relevant aspects of water management, e.g., water pollution control, flood risk management and preventive measures, land-use, urban development at all levels (local, regional, and national), monitoring and forecasting overflows, early warning, simulation and optimisation procedures.

Monitoring of water pollution is a complex task and is carried out using terrestrial based automatic and manual devices. Currently most information comes from fixed-site, terrestrial monitoring stations which provide only a partial picture of the water pollution situation due to the lack of spatial representation of water pollution sources. In addition, forecasting of physical parameters and impact of water pollution are mainly local and often highly variable at short distances. Knowledge of the relative contribution of different sources (agriculture, households, industries, aerial deposits) is often important to verify the effectiveness of control measures. Within the context of dynamic optimisation, the problems in water pollution control involve multiple, conflicting objectives in a highly complex search domain and can be regarded as real-time Multi-objective Optimisation Problems (MOPs). They can be formulated in a design model for the monitoring network as follow:

$$Network_{MOP} = optimize : f(x) = \{f_1(x), f_2(x), .., f_n(x)\}\ subject\ to\ x = (x_1, x_2, .., x_n) \in X$$

where fi(x) is the model of monitoring network that consists of ith monitoring objective functions to be optimised, x is a set of variables (i.e., decision parameters) and X is the search domain. The term "optimise" means finding the ideal network in which each monitoring objective function corresponds to the best possible value by considering the partial fulfilment of each of the objects. More specifically, this monitoring network is optimal in a way such that no other networks in the search domain are superior to it when all objectives are considered. The monitoring network is a system of satellites and ground stations for providing real-time monitoring to detect impact of the pollution sources implicated in water quality changes. This network implements a set of monitoring stations spread over the whole geographic area of the region to provide reliable information on a continuous basis. The design model for the monitoring network requires specific objectives for an efficient and effective monitoring system that will address many operational and management requirements related to water quality and quantity parameters. These monitoring objectives can be consisted of several parameters to optimise: monitoring violations of the water quality standards specified for each watershed, estimating pollution loads from each watershed unit, determining water quality status that help understanding the long and short term trends of temporal variations, identifying the causes and sources affecting water quality changes, supporting utilization of water resources, the use of water quality modelling that support scientific water quality management functions, etc. The use of complex functions to produce further evaluations for the monitoring network requires flexible and power search algorithms that do not need mathematical constraints on the form of the objective functions. Dynamic Metaheuristic Algorithms (DMAs) (which are based on the ideas of Artificial Intelligence (AI)) potentially have these capabilities to produce set of high quality real-time designs that can model more closely and easily the monitoring parameters. Therefore, it is almost impossible even for an experienced and higher-level designer to find an optimal network design by the current used methods which do not provide spatial representation to the whole situation and lack the ability to select 'interesting' contingencies for which to optimise. Once such designs are obtained, the technical user will be able to select an acceptable network design by trading the competing monitoring objectives against each other and with further considerations. The final design should be robust (i.e., performs well over a wide range of environment conditions), and flexible (i.e., allows easy adaptation after the environment has changed).

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The Stockholm International Water Institute (SIWI) is a policy institute that contributes to international efforts to find solutions to the world's escalating water crisis. SIWI advocates future-oriented, knowledge-integrated water views in decision making, nationally and internationally, that lead to sustainable use of the world's water resources and sustainable development of societies.

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